THE DOMAIN OF PHYSIOLOGY AND ITS RELATIONS TO MEDICINE.*

PHYSIOLOGY is of medical parentage, was reared by medical men and is still housed and fed by medical faculties. Still it is medicine against which its frequent declaration of independence is directed. Medicine is a practical science and is too inexact, and physiology wishes to be a pure, exact science. It, therefore, tries to keep aloof from medicine and manifests a longing for association with or, still better, for a reduction to, physics and chemistry. It urges, furthermore, that the affiliation with medicine binds physiology down to only one species of animal with intricate, complicated conditions, while it would be more beneficial to physiology if it would direct its energies towards a study of monocellular organisms where the conditions are so simple.

Permit me to discuss briefly the domain of physiology and the importance of its relations to medicine as they present themselves to my mind. There can be no doubt whatsoever that physiology has a perfectly legitimate object entirely of its own. Perhaps I may elucidate this statement in the following crude way. All natural phenomena impress us in two ways—as matter and as force. The phenomena are either inanimate or animate. The studies of inanimate matter are to be found in mineralogy, crystallography, in a part of chemistry, etc. The studies of the forces or energies of inanimate phenomena are carried on by physics and physical chemistry. In the fields of living phenomena, matter is studied by gross and minute anatomy and by descriptive zoology and botany, or in short by morphology. The studies of the forces, the energies or the functions of living matter, are the proper domain of physiology. Now this definition permits a few deductions. All these four divisions are bound, as sciences, to have something in common in their methods of investigation; they must employ the inductive method and must strive to reach in their results that degree of certainty which the nature of each individual science permits it to attain. But the four divisions differ greatly from one another; each one has its own subjects and laws and its own problems, which have to be solved by methods peculiarly adapted for each division. It is certainly clear to every one that it can not be the essential task of animal morphology to reduce itself to mineralogy because it can be demonstrated that some anatomical objects contain lime and other mineral substances. It seems to me it ought to be also clear to every one that it can not be the sole task, and not even the essential task, of physiology to reduce itself to physics and chemistry because some or many of the living phenomena are governed to some extent by known laws of physics and chemistry. Physiology has to study the functional side of life, and in the attempts to elucidate its complex phenomena it certainly has to employ also the known facts of physics and chemistry. But if we would confine the domain of physiology to such parts only which can be interpreted by the laws of physics and chemistry of to-day, we would have to give up nine hundred and ninety-nine out of a thousand of the phenomena of life as still inappropriate for physiological study. The four divisions of the natural sciences are closely interwoven and each one can, of course, profit by the experience of the others. Boyle, Mayow, Priestley, Lavoisier and others attempted to unravel the nature of oxygen, nitrogen and carbon dioxide gas by the aid of experimental studies of the physiology of respiration. The physicist or the chemist employs any method which would help him

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to shed light upon his subject, but physics and chemistry have methods peculiar to themselves and that is the secret of their great success. And so it should be with physiology. However, when physiology broke away from medicine, it ran into the arms of physics and chemistry and is still largely there. The early successes which have attended the new venture, which, by the way, is the case with every new venture, led to the conception that this is the most desirable, the most natural union. An analysis, however, of the work in animal physiology in the last few decades will show the fact that the too great gravitation towards physics and chemistry prevented the development in many directions of a purely physiological character.

I contend that physiology is an independent science with a clear outline of its domain, but it ought to direct its declaration of independence not only towards medicine, but also towards such exact sciences as physics and chemistry.

As to the standard of precision and exactness to be required of physiology, let me say this. Certainly no physiological problem can be solved with that exactness, with that absolute reliability which is now the standard for a good many problems in physics and chemistry. Above all in the studies of the energies of life we lack the controlling factor of synthesis. If we can produce synthetically urea or sugars or other dead constituents of a dead or living body, we can not yet make synthetically the smallest living organ of the smallest homunculus. But what of it? Each science has its own degree of attainable exactness. Physics and chemistry have one standard and paleontology or geology is bound to have another standard of exactness. There is no one standard of exactness for all sciences. The scientific demand upon work in any science is to strive for that degree of exactness which is attainable in each specific field of investigation.

I contend, further, that physiology ought not and can not be properly developed upon the basis of a morphological unit. We might just as well attempt to put up the mineral crystals as a basis for the study of physics.

I may say, further, that in my opinion the knowledge of vital energies would progress more rapidly if we would be guided in our investigations by the view that the actual processes in the phenomena of life are of a very complex nature. The desire to reduce the multiplicity of phenomena to a few simple principles is a philosophical importation of a psychological origin. Certainly premature attempts to offer simple interpretations for complex phenomena have often been an obstacle for a further development of our knowledge of the actual processes.

Physiology, however, may take some useful hints from the other sciences. It may learn from such exact sciences as physics and chemistry that the exactness and dignity of a science do not suffer by coming into intimate contact with the necessities of daily life. On the contrary, we find that those chapters of physics and chemistry whose results found practical application, are best developed. The contact of a science with life and its actual necessities works, on the one hand, as a stimulus to investigation, and, on the other hand, as a corrective against an indulgence in mere hobbies. The experimental method as such is no talisman against such scholastic degeneration. A study of the literature of the last few decades will show that physiology, too, could well stand such a corrective.

Physiology could also learn from morphology that a special attention to the human being does not necessarily lead to a neglect of the uniform study of the entire

animal kingdom. The marvelous complete studies of gross and minute human anatomy, which was of such immense service to pathology and surgery, was in no way an obstacle to the brilliant development of the broad science of zoology.

There is, however, one difference between the studies of the energies of inanimate phenomena and the studies of the vital energies to which I would like to call special attention. For physics there is only one kind of energies; they are all normal. If the physicist meets with conditions which apparently do not agree with some established law, he does not transfer these conditions to a pathologist in physics for further investigation. On the contrary, he is only too glad to have such an opportunity; it usually leads to an elucidation of the old law, or still better, an entirely new law might be discovered. When Kirchhoff was surprised by the apparently contradictory fact that by the addition of the yellow light of sodium to the sunlight the dark *D*-lines in the spectrum instead of becoming lighter became still darker, he did not turn away from the problem. On the contrary, he was glad of this opportunity; in fact, as he stated once, he was longing to meet such a complete contradiction. The result was the establishment of the law of the proportion between emission and absorption of light and the creation of the nearly new science of spectral analysis. Or to quote a more recent instance, the exceptions to van't Hoff's law of osmosis which were met with in salt solutions and which had been displayed by some as a proof against the validity of that law, served Arrhenius as a basis for the establishment of the far-reaching law of electrolytic dissociation. It is totally different, however, with physiology. Its domain is, as we saw above, the study of the functional side of living phenomena. Here, however, we find the artificial and unsound distinction between normal and abnormal functional phenomena. Physiology set up some laws; and if conditions appear which do not fit in with these laws, physiology declines to deal with them, it refers you to medicine. Are the laws governing the vital functions under pathological conditions actually different from those controlling the functions in health? Certainly not. The laws which physiology establishes must be capable of covering the functional phenomena in all conditions of life. The apparent exceptions in disease should serve in physiology, as in physics, to unravel the real nature of the laws governing the functions of living phenomena, whether they occur in health or in sickness. For instance, the processes occurring while the body is in a state of fever should give a clue to the understanding of the mechanism of the constancy of the elevated temperature of warm-blooded animals. Or the conditions prevailing when urine contains albumin should be seized as a means of studying the remarkable phenomenon in the normal urinary secretion, namely, that of all the endothelial cells of the body the kidney endothelia alone do not permit normally the passage of albumin. Or the conditions of the blood and the lung tissues in pneumonia could serve as an aid in studying the factors concerned in the formation of fibrin. And so on and so on in many thousand instances of daily occurrence. Some very important discoveries in physiology were thus recently brought to light through medical experience and by medical men, with hardly any aid from physiology. The anatomy of the cases of myxœdema and cretinism and the results of the complete removal of the thyroid gland for goitre revealed the physiological importance of that ductless gland for which physiologists, with one single exception, had no interest. This discovery helped at the same time to establish and to introduce

into physiology the far-reaching conception of internal secretion. Furthermore, the observation of Bouchard, Lancereaux and other medical men of the occurrence of a degeneration of the pancreas in cases of diabetes mellitus, led to the discovery, by two medical men, of the remarkable fact that the complete removal of the pancreas in dogs leads to diabetes. This discovery demonstrated at the same time the further principle that even glands with a distinct external secretion have besides a physiological importance for the body by virtue of their internal secretion. In the long list of workers on this subject we hardly find a single physiologist.

I could quote a good many more instances in which medical studies brought out important physiological facts and how physiology is slow to avail itself of such golden opportunities.

The physicists are only too glad to meet with exceptions; the physiologists run away from them. Is there any well-founded justification for such a course in physiology? I believe none. I believe it is simply an erroneous position. It would lead me too far to attempt here a discussion of the causes which led to this position in physiology. But I say without hesitation that this position is deplorable, is harmful to physiology as well as to medicine. Animal experimentation is the essential method of developing physiology. Now then nature makes daily thousands of experiments upon man and beast and physiology refuses to utilize them for its own elucidation. I feel quite sure that a study of the functional processes in pathology, or at least the systematical taking up of physiological problems indicated by pathological processes, by minds naturally endowed and properly trained for physiological studies, would greatly elucidate the proper sphere of physiology itself and would at the same time be of incalculable value to pathology and medicine.

And medicine is greatly in need of such a physiology. I am afraid that the actual situation in medicine is not fully grasped even by a great many of its enlightened disciples. To state the critical point in a few words: The actual disturbance in most of the diseases is primarily of a functional nature, but the essential part of the present knowledge in medicine is morphological in its character! This discrepancy is due to the uneven development of the sciences of medicine. When the empirical art of medicine awoke to the necessity of acquiring a scientific basis, it found ready for its disposal an already well-defined precise anatomy, but only a vague, incoherent physiology. It set out and continued to work in the precise lines of anatomy, in which it attained a marvelous completeness. By this step, however, morphology became the dominant factor in medicine and the definition of a disease became inseparably coupled with that which was found in the body after it succumbed to the disease. When at a later period physiology also became a precise science, it broke away at the very onset of its regeneration from medicine; it wished to be exact, to be a pure science, and thus gained no influence upon pathology, which it refused to study. So it came about that medicine is made up of a complete knowledge of the anatomical conditions after death, of nearly a complete morphology of the symptoms of the disease during life, but of only a vague, makeshift mechanical interpretation of the functional disturbances during the actual course of the disease. The last decades have seen the birth and marvelous growth of the knowledge of the ætiology of disease. Animal and vegetable invaders were recognized as the essential cause of many diseases. But the study of the functions of the body whose lot it is to grapple with the invaders

received only a secondary attention, and that again essentially from morphological quarters. At the present time still more knowledge is being diligently added to the stores of medical wisdom. Chemistry has taken a powerful hand in the studies of physiology and pathology and is attaining brilliant results. But we should not be misled. The studies are essentially morphological in their nature. It is physiological and pathological chemistry, and but very little chemical physiology and pathology. Even if the hopes of the new school of brilliant chemical investigators will, indeed, be realized, viz., that in a not far off future they will know the structure of proteids and all their constituent bodies, it will be the knowledge of the proteids of the dead bodies, it will be a brilliant post-mortem chemistry. Living animal matter, however, is something else than dead proteids, as living plants are something else than carbohydrates, although the knowledge of the latter has already reached the ideal stage where some of them can be produced synthetically. No, a study of life, normal and abnormal, is essentially a study of energy, of function; of course, the knowledge of the underlying morphology, dead or living, is a prerequisite for such studies. And let me state right here that there seems to be a difference in the make-up of the human mind with regard to the different studies. Some are more apt and better endowed to grapple with the problems of energy, and others again have natural talents for the science of morphology. Only few, however, have the good fortune of becoming educated in the lines of their natural endowments, and still fewer have the genius to work out their natural destinies against all odds, against all education and training. Now the men who did and who now do the original work in the medical sciences received their training in the studies of medicine, four fifths of which is profoundly developed, magnificent morphology. We can not wonder, therefore, that most of the original contributions to the medical sciences are essentially of a morphological character. Even in the very recent brilliant additional departments of medicine, in bacteriology and chemistry, the research work is, as already stated above, for the most part of a morphological stamp. It is true that a few men of genius in medicine, Cohnheim for instance, broke their acquired chains and made an attempt to study pathology from a functional point of view. Such attempts, however, were not many and their permanent influence is not extensive. What is now termed general pathology or even pathological physiology consists, in the first place, of a collection of histological, bacteriological and chemical facts of a general but essentially of a morphological nature, including at the same time the applications of a few well-established physiological facts to pathology and a few results from direct experimentation in pathology. That is not a study of physiology under pathological conditions, and certainly not a study of general physiological laws which can be stimulated by and derived from a study of pathological processes. And it is just this kind of study which is missing, and which could be developed only by a purposeful and concerted action of the men who have a training in the study of the functional side of life, among whom there are surely many who have a natural endowment for such studies.

The following review of the present situation in medicine will show us the place left vacant by physiology and the disastrous consequences. The studies of pathological anatomy extend over all divisions of medicine, are lucid and nearly complete. Diseases which are exclusively due to palpable anatomical changes are quite well understood. Their harmful effects are, for

the most part, of a mechanical nature. In proportion as they are understood, these forms of disease become amenable to an efficient treatment; it is mechanical, it is surgery.

The studies of the ætiology of diseases revealed and continue to reveal many of the foreign originators of disease, the animal and vegetable invaders of the living organism. This new and lucid knowledge led again to some effective measures in the treatment of diseases, it led to clear plans in preventive medicine, it gave means to the surgeon to enter with impunity into the interior of living organisms, and in a few instances it discovered actual remedies for non-surgical diseases.

But most diseases are something more than mechanical disturbances, or exclusively anatomical changes. There is, in the first place, that large group of so-called functional diseases which has no pathological anatomy, and for which clinicians have very little interest. But even those numerous diseases in which the post-mortem examination revealed distinct anatomical changes were only results of the advanced stage of the disease. The disease during life consisted primarily surely in disturbances of a functional character, in reactions to foreign causes, reactions of living energies, the physiology of which we have possibly as yet not even an inkling of. The so-called organ physiology which appears to the teachers of physiology to be so extensive that it can hardly be taught to students of medicine in one year's lectures, is of astonishingly modest assistance to the understanding of the actual processes of disease. For instance, in the present knowledge of the entire section of the diseases of the respiratory tract, physiology has hardly any share. The knowledge of the few physiological principles which are applied there can be acquired in one hour's instruction. The extensive knowledge in this chapter of pathology is essentially of a morphological nature. Do the functions of the involved organs take no part in these pathological processes? Most certainly they do; but we know too little of it, and the clinician passes over the gap with some makeshift mechanical explanations. The same is true in neurology; in fact, in nearly every chapter of internal medicine. It is impossible to dwell here on the particulars of our subject. What is the result? First-class clinicians employ their brilliant faculties in continually developing the morphology of diseases and their diagnosis. But treatment? There is either a nihilism pure and simple, or some sort of a symptomatic treatment is carried on with old or new drugs upon a purely empirical basis. Or there is a great deal of loose writing upon diet, air, water, psychotherapy and the like, and a great deal of semi-popular discussion in international, national and local meetings and popular prize essays on the best methods of treatment—with a net result of only a very modest actual benefit for the poor patient, who in addition to his affliction has now to feel the tight grip of the modern health officer. There is no efficient treatment of internal diseases in any way comparable with the specific surgical treatment of mechanical diseases, no specific quelling, correcting or curbing of primarily functional disorders. And there never will be such a specific functional therapy before there will be a physiology which, like physics, will be only too glad to meet with many exceptions in order to properly understand all the rules by which the energies of all grades of living phenomena are guided.

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